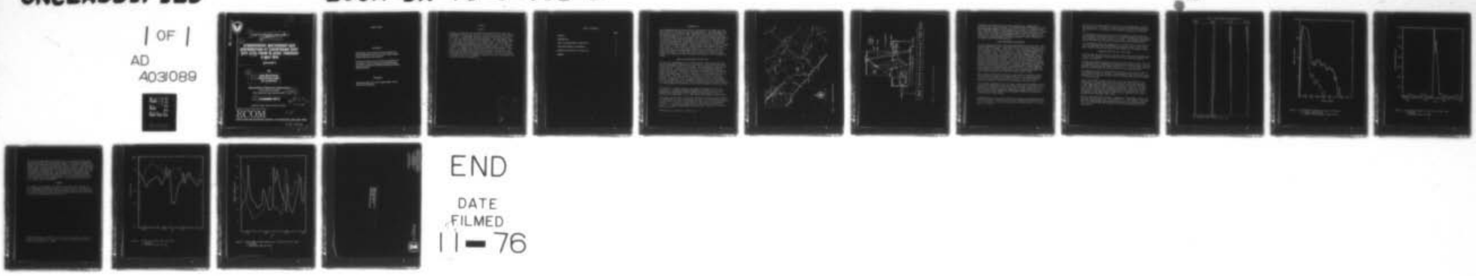
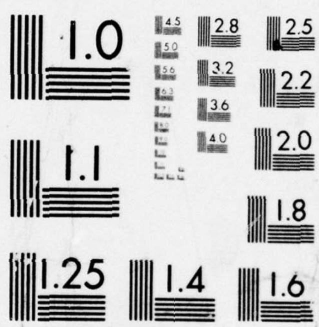
AD-A031 089 ARMY ELECTRONICS COMMAND WHITE SANDS MISSILE RANGE N--ETC F/G 4/1
ATMOSPHERIC WATERDROP SIZE DISTRIBUTION AT CAPISTRANO TEST SITE--ETC(U)
SEP 75 D H DICKSON, R B LOVELAND, W H HATCH

UNCLASSIFIED ECOM-DR-75-3-VOL-1 NL

1 OF 1
AD
A031089



END
DATE
FILMED
11-76


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

AD A031089

(2)

(9) RESEARCH AND DEVELOPMENT TECHNICAL REPORT,

(14) ECOM-DR-75-3-Vol-1

(6)

ATMOSPHERIC WATERDROP SIZE DISTRIBUTION AT CAPISTRANO TEST SITE (CTS) FROM 16 APRIL THROUGH 11 MAY 1974.

VOLUME I.

By

(10) David D. H. DICKSON

Radon B. LOVELAND

W. H. HATCH

Atmospheric Sciences Laboratory

US Army Electronics Command

White Sands Missile Range, New Mexico 88002

(12) 14p.

(11) September 1975

Approved for public release; distribution unlimited.

ECOM

UNITED STATES ARMY ELECTRONICS COMMAND - FORT MONMOUTH, NEW JERSEY 07703

400 844 LB

NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The citation of trade names and names of manufacturers in this report is not to be construed as official Government indorsement or approval of commercial products or services referenced herein.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.

ABSTRACT

VOLUME I

Atmospheric waterdrop size distribution was measured by a laser fog nephelometer at Capistrano Test Site, California, from 16 April through 11 May 1974. Liquid water content, extinction coefficient, and visibility were calculated from the data obtained. The nephelometer data were collected from sunset to sunrise nightly for 25 consecutive nights. Fog conditions were recorded on 4 of these nights. A time format of 5-minute samples separated by 5-minute pauses was used. The data are presented in tabular form referenced to channel number (i.e., nominal radius). For comparison, the 64 channels of data were treated in four groups of 16 channels each as well as one group of 64 channels. This volume contains general narrative and background. Volume II contains tabularized data for CTS-1 through CTS-5, Volume III for CTS-6 through 10, Volume IV for CTS-11 through 15, Volume V for CTS-16 through 20, and Volume VI for CTS-21 through 25.

TABLE OF CONTENTS

INTRODUCTION

The micrometeorological characterization program at Capistrano Test Site (CTS) (Figure 1) included a laser fog nephelometer. The nephelometer was emplaced on top of a 60-foot tower approximately 300 meters northwest of the 500-meter pad (Site I). This placed the instrument sampling volume at the same height as the high-energy laser path but displaced horizontally. The authors of this report considered this location to be reasonable for a single-point measurement of waterdrop size distribution. The data were collected from sunset to sunrise nightly from 16 April to 11 May 1974, a total of 25 consecutive nights. Fog conditions were recorded on 4 of these nights (16%). A time format of 5-minute samples separated by 5-minute pauses was used. This data report consists of six volumes. Volume I contains site location, instrumentation description and calibration, and graphic depiction of one fog night and one relatively clear air night. Volumes II through VI contain the tabularized data for all 25 consecutive nights.

LASER FOG NEPHELOMETER DESCRIPTION

The laser fog nephelometer* is an electro-optical device which directly measures atmospheric waterdrop size distribution, from which liquid water content and visibility** are calculated. The nephelometer system has two basic sections: a commercially available laser nephelometer optical head*** and the signal processor electronics developed by the Atmospheric Sciences Laboratory. As shown in Figure 2, a continuous-wave helium neon (HeNe) laser beam (6328 Å, 4 mW) is focused in an airstream created by a suction pump. This beam intersects the field of view of a radiation detector. Ambient radiation is suppressed by an optical filter placed in front of the detector, with a bandpass centered at the laser wavelength. The light pulses produced by the forward scattering from the water droplets passing through the intersection are processed through the signal processor

*Harry Folster, David H. Dickson, and Radon B. Loveland, "A Laser Fog Nephelometer: Its Description, Calibration, and Field Testing," Third Symposium on Meteorological Observations and Instrumentation, 10-13 February 1975, Washington, D. C., published by AMS, Boston, Massachusetts.

**An average of Equations (9) and (10) (Smithsonian Meteorological Tables, 6th revised edition, 1951, pp 454-455) was used. The extinction coefficient α equals $N\pi r^2 Q/V$, where V is the volume in question, N is the number of droplets, r is the droplet radius, and Q is the efficiency factor (H.C. Van de Hulst, Light Scattering by Small Particles, John Wiley & Sons, Inc., 1957, pp 14, 415.

***Manufactured by Arthur D. Little, Inc.

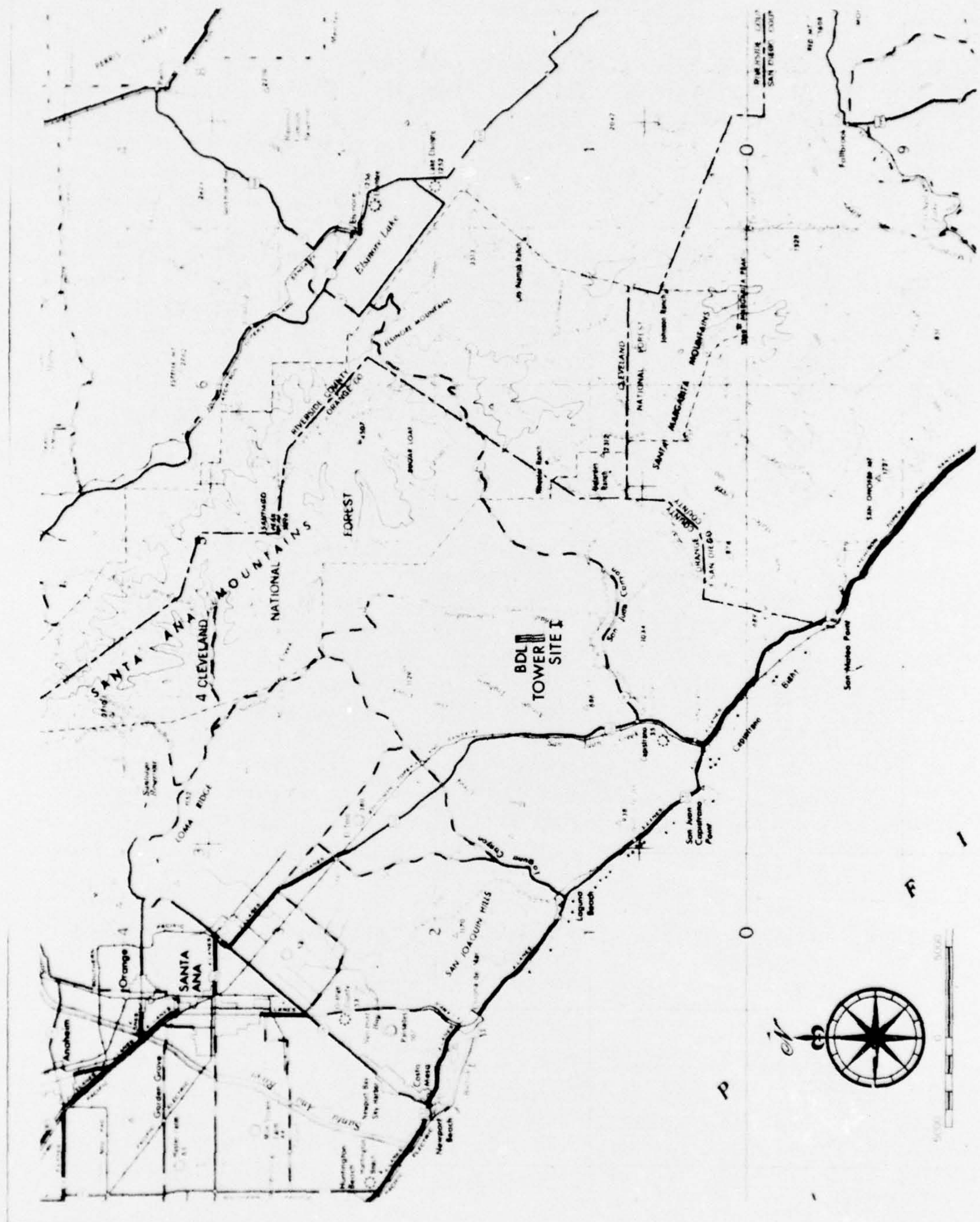


Figure 1. Capistrano Test Site

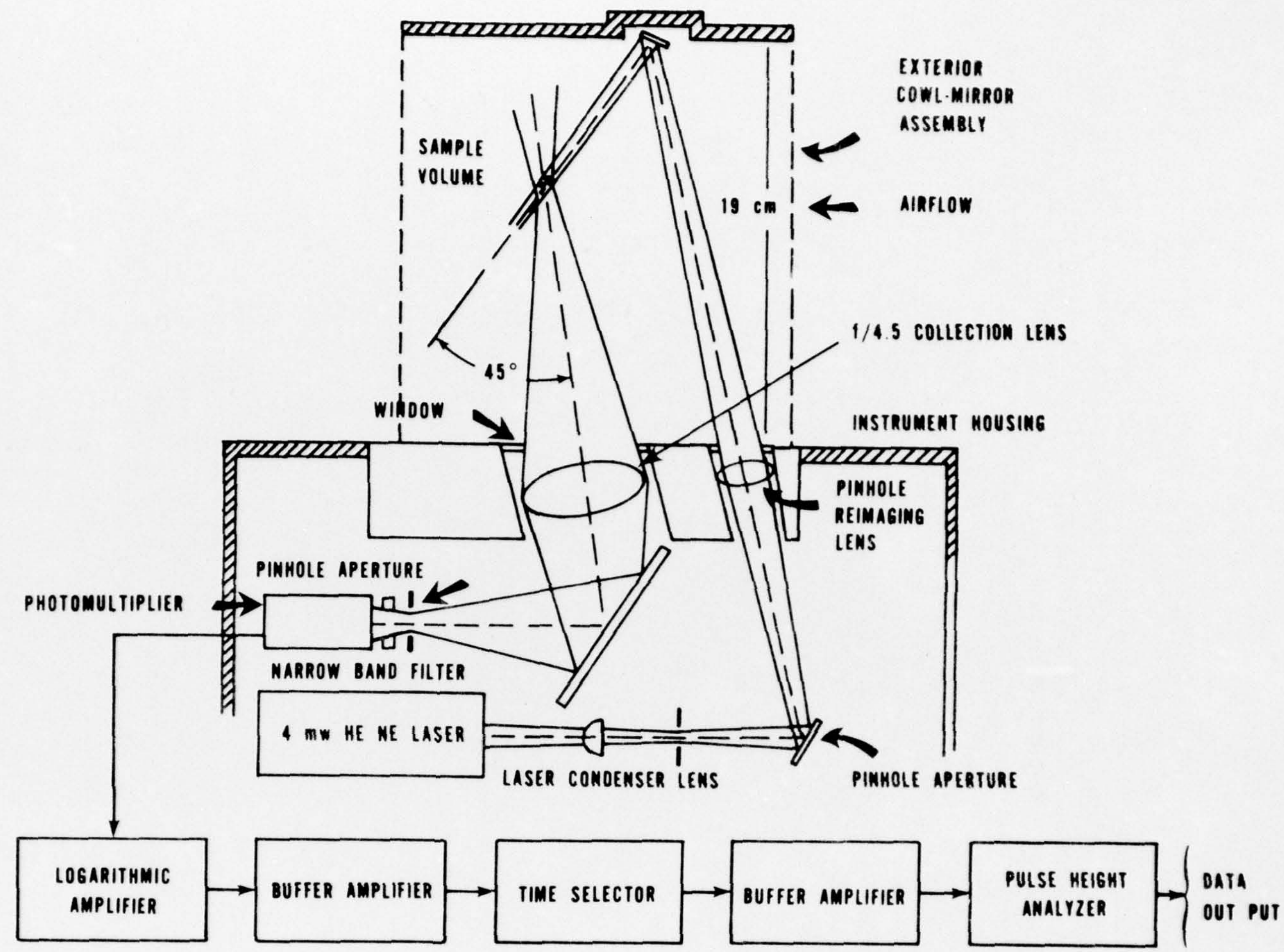


Figure 2. Laser Fog Nephelometer System.

electronics section* and are stored and analyzed by a computerized 64-channel pulse height analyzer. The nominal radius of the water droplets and the channel number are correlated, and the total air volume (in this case, 1500 cm^3) sampled is determined by the intersection of the laser beam with the field of view of the radiation detector, the airflow rate, and sample time. The laser fog nephelometer has a lower- and upper-level discrimination of approximately 3 and 242 micrometers radius, respectively, for water droplet size determinations.

LASER NEPHELOMETER CALIBRATION

The laser nephelometer was calibrated experimentally with four basic water droplet generation systems used to produce water droplets ranging in radius from 3 to 242 micrometers. These were: (1) a high-voltage, dc-charged syringe needle, (2) a spinning disk, (3) a sonic ultramist generator, and (4) a humidifier spray. The combination of these systems offered a size range of water droplets spanning that of the laser nephelometer system. Ideally, any water droplet generation system used for calibration should produce a monodisperse distribution, but no such distribution could be obtained in any of these systems. The sonic ultramist generator and the spinning disk produced a narrow band of droplet sizes with a well-defined maximum in the observed distribution. Although monodispersed droplet distribution should be produced with the charged needle, surface roughness at the needle tip caused spurious droplets smaller than the normal size. Visual observations with a stroboscopic light indicated the presence of these droplets spraying away from the primary droplet stream.

Other problems encountered with the charged needle included the effects of the electrical charge on the water droplet as many droplets were repelled from the surface of the collection slide. This difficulty was partially overcome by neutralizing the charge on the glass slide.

Water droplets generated in each of these systems passed through the sample volume of the nephelometer and collected on the glass slides which were coated with silicone oil (Dow Silicone 200) of 10,000 centipoise viscosity. The collected droplets were then covered with another coated slide for preservation and were immediately photographed through a microscope with a 35-millimeter reflex camera.

*A report, "Signal Processing and Display Electronics for Light Scattering Particle Detection," detailing the schematic and description of the signal processor electronics is being prepared for publication by R. B. Loveland and D. H. Dickson.

Droplet size was measured from projections of the photographic negative onto grid paper. The number of droplets measured varied from 30 to 1000 per negative, with a minimum of five negatives analyzed per calibration test.

The photographic-microscope droplet size measurement system calibration was checked by using cylindrical rods of a known diameter and glass spheres whose diameters fell within a given size range. Each negative contained a calibrated scale which had been integrated into the microscope optics.

The nephelometer output was compared to the distribution of water droplet sizes as determined from the photographic negatives, and a value of the water droplet radius was assigned to each channel of the computer output.

GRAPHICAL DEPICTION OF TYPICAL DATA

Data from one fog night and one relatively clear night are presented graphically in this volume, and the remaining data are presented tabularly in Volumes II through VI.

The fog data presented graphically were collected 16 and 17 April 1974; the fog appeared to be a combination of radiation and advection types. The temperature measured near the sample volume was 10° ± 1.0°C, and the relative humidity varied between 88 and 100 percent for the fog life cycle.

The relatively clear air data presented occurred 17 and 18 April 1974. A high stratus overcast was present. The temperature near the sample volume averaged 12.5°C, and the relative humidity remained constant at 75 percent for the data period.

Table 1 and Figure 3 show a comparison of the size distribution of the waterdrops on a foggy night and a relatively clear night at 0120 hours. On the foggy night as compared to the relatively clear night, over twice as many water droplets were counted at 0120 hours. There is a distinct shift in the particle size distribution toward the larger sizes on the foggy night. Four percent of the droplets are in the range of 7 to 10 micrometers on the foggy night at 0120 hours as compared to less than 1 percent on the relatively clear night.

Figure 4 shows the rapid increase in atmospheric liquid water content with fog onset at 0100 hours (4.0×10^{-3} gm/m^3 to 1.7×10^{-1} gm/m^3). The lower levels on liquid water content before this fog are only slightly higher (1.4×10^{-3} gm/m^3) than the average levels during relatively clear air measurements.

TABLE 1. CHANNEL NUMBER AND NOMINAL RADIUS (μm)

Channel Number	Nominal Radius	No. Drops (1)*	No. Drops (2)**
1	2.6	7	0
2	2.8	1290	3664
3	3.0	2929	4201
4	3.2	4095	2383
5	3.4	4383	1422
6	3.7	3993	918
7	4.0	3596	662
8	4.3	3262	513
9	4.6	3028	403
10	4.9	2897	378
11	5.3	2129	195
12	5.7	984	82
13	6.1	449	46
14	6.6	195	11
15	7.1	95	12
16	7.6	50	15
17	8.1	47	10
18	8.8	44	14
19	9.4	66	9
20	10.1	39	4
21	10.9	42	6
22	11.7	69	7
23	12.6	81	5
24	13.5	75	7
25	14.5	63	4
26	15.6	75	3
27	16.8	68	3
28	18.0	36	4
29	19.4	59	2
30	20.8	45	0
31	22.4	46	0
32	24.0	46	2
33	25.8	52	2
34	27.8	48	0
35	29.8	24	0
36	32.1	29	0
37	34.5	26	0
38	37.1	26	0
39	39.8	36	0
40	42.8	30	0
41	46.0	31	0
42	49.4	23	0
43	53.1	26	0
44	57.1	22	0
45	61.4	24	0
46	66.0	9	0
47	70.9	7	0
48	76.2	12	0
49	81.9	9	0
50	88.1	2	0
51	94.6	1	0
52	102	1	0
53	109	3	0
54	118	1	0
55	126	0	0
56	136	0	0
57	146	0	0
58	157	0	0
59	169	0	0
60	181	0	0
61	195	0	0
62	210	0	0
63	225	0	0
64	242	0	0

*(1) 0120 hours 17 April Fog Data
**(2) 0120 hours 18 April Relatively Clear Air Data

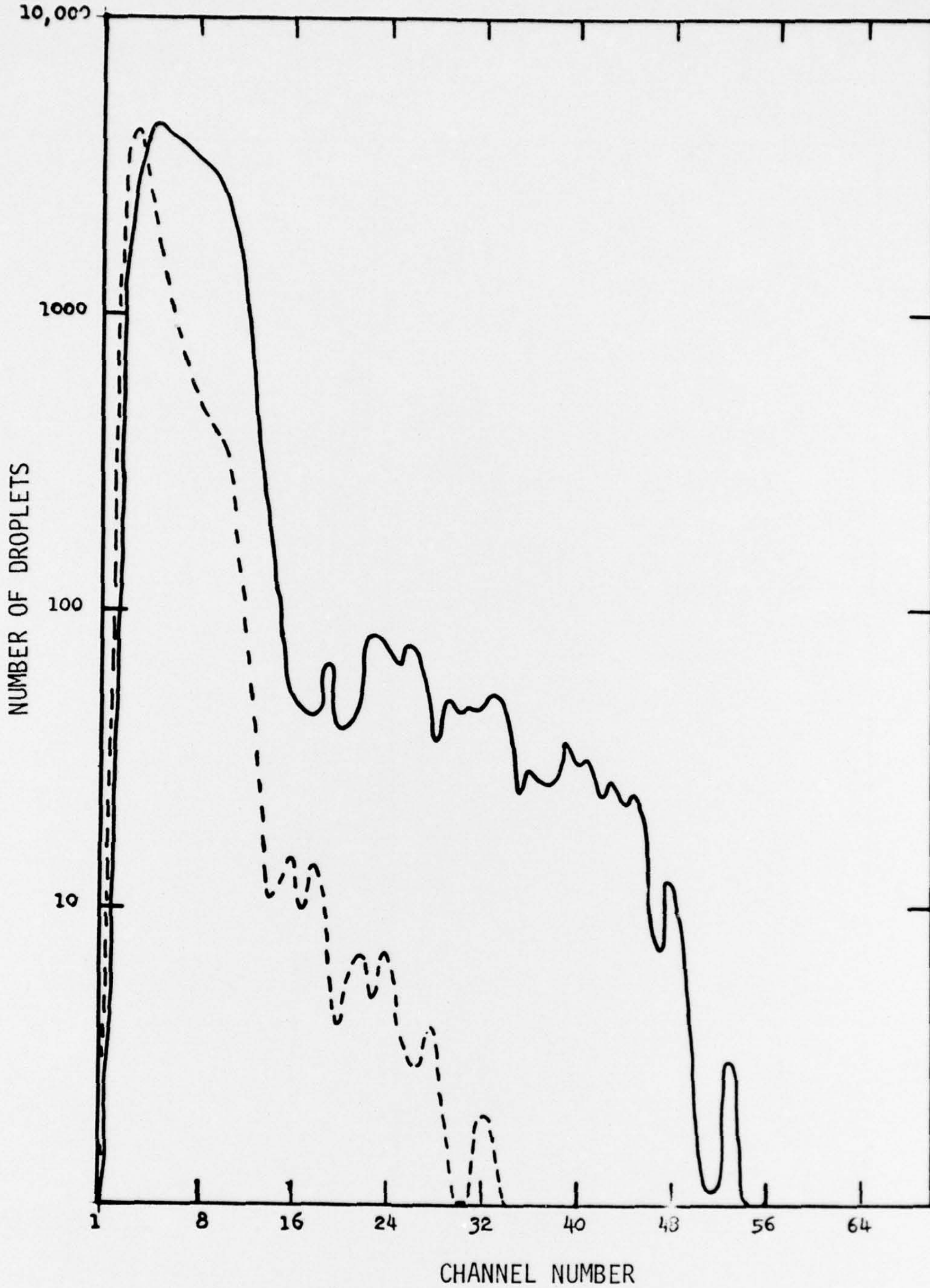


Figure 3. Distribution of waterdrop sizes at 0120 hours.
—— 17 April 1974 Fog Data
--- 18 April 1974 Relatively Clear Air Data

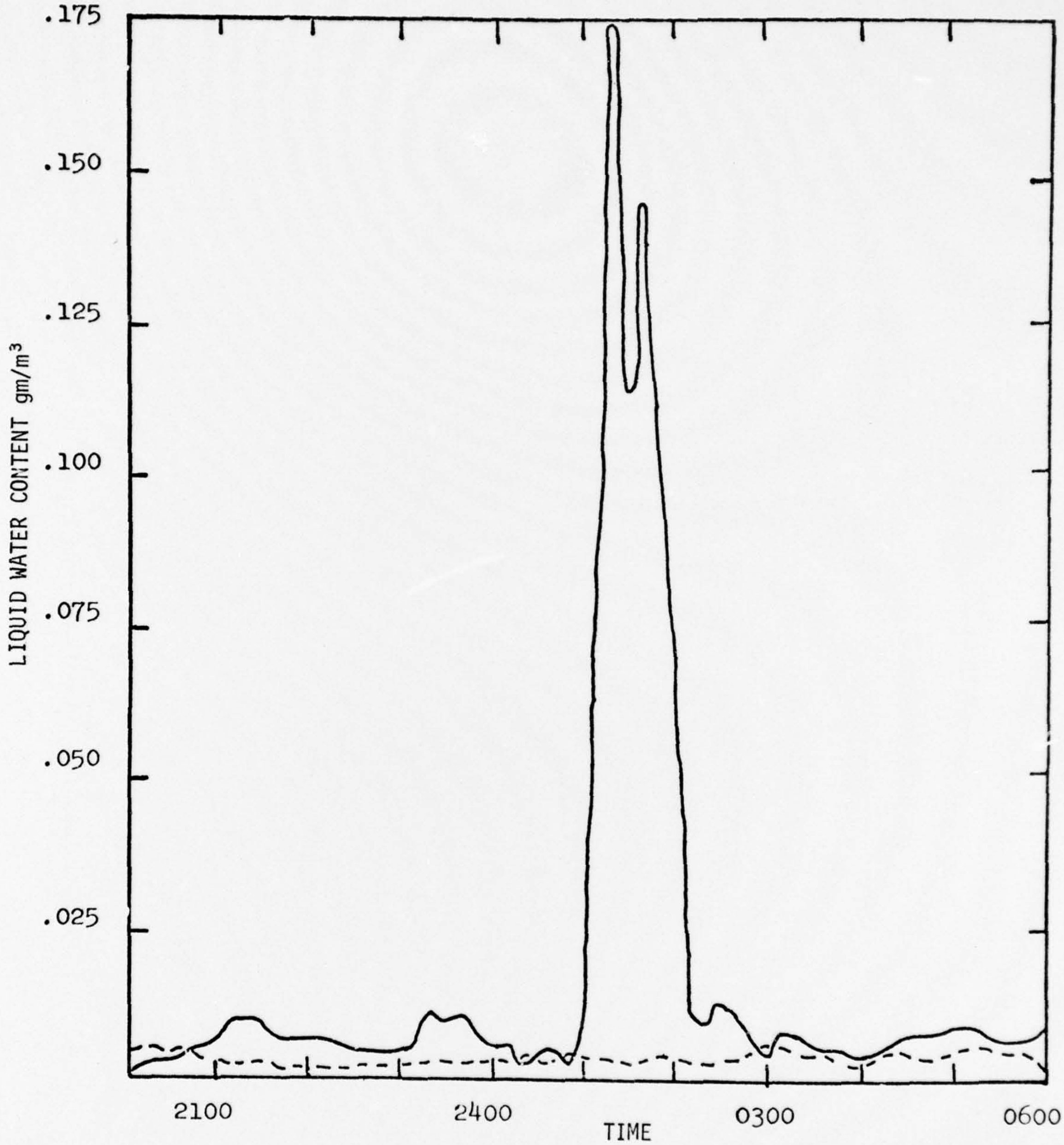


Figure 4. Liquid water content as a function of local time.
—— Fog Data
--- Relatively Clear Air Data

Figure 5 indicates that the visibility is quite variable in both cases. The visibility before fog onset (0100 hours) is considerably greater for the clear air case than for the fog. However, in the early morning hours (0300), there is very little difference in the two cases. The distribution of waterdrop size during the tests and Figures 5 and 6 indicate that the total number of droplets does not influence calculated visibility as much as droplet size distribution. The distributions of atmospheric water droplets measured by the described technique are in general agreement with the results of other investigators.* The tabularized data for the test period are listed chronologically. Fog was observed during tests CTS-1, CTS-6, CTS-7, and CTS-15.

SUMMARY

No comments or conclusions are drawn from the data since the data are basic atmospheric parameters presented in general terms. The data are a valid indication of fog life cycles, waterdrop size distribution between 2 and 242 micrometers radius, and liquid water content for the Capistrano Test Site during the specified time period.

---

*Gayle S. Rinehart, ECOM-5247, "Fog Drop Size Distribution - Measurement Methods and Evaluation," Atmospheric Sciences Laboratory, White Sands Missile Range, New Mexico, 1969.

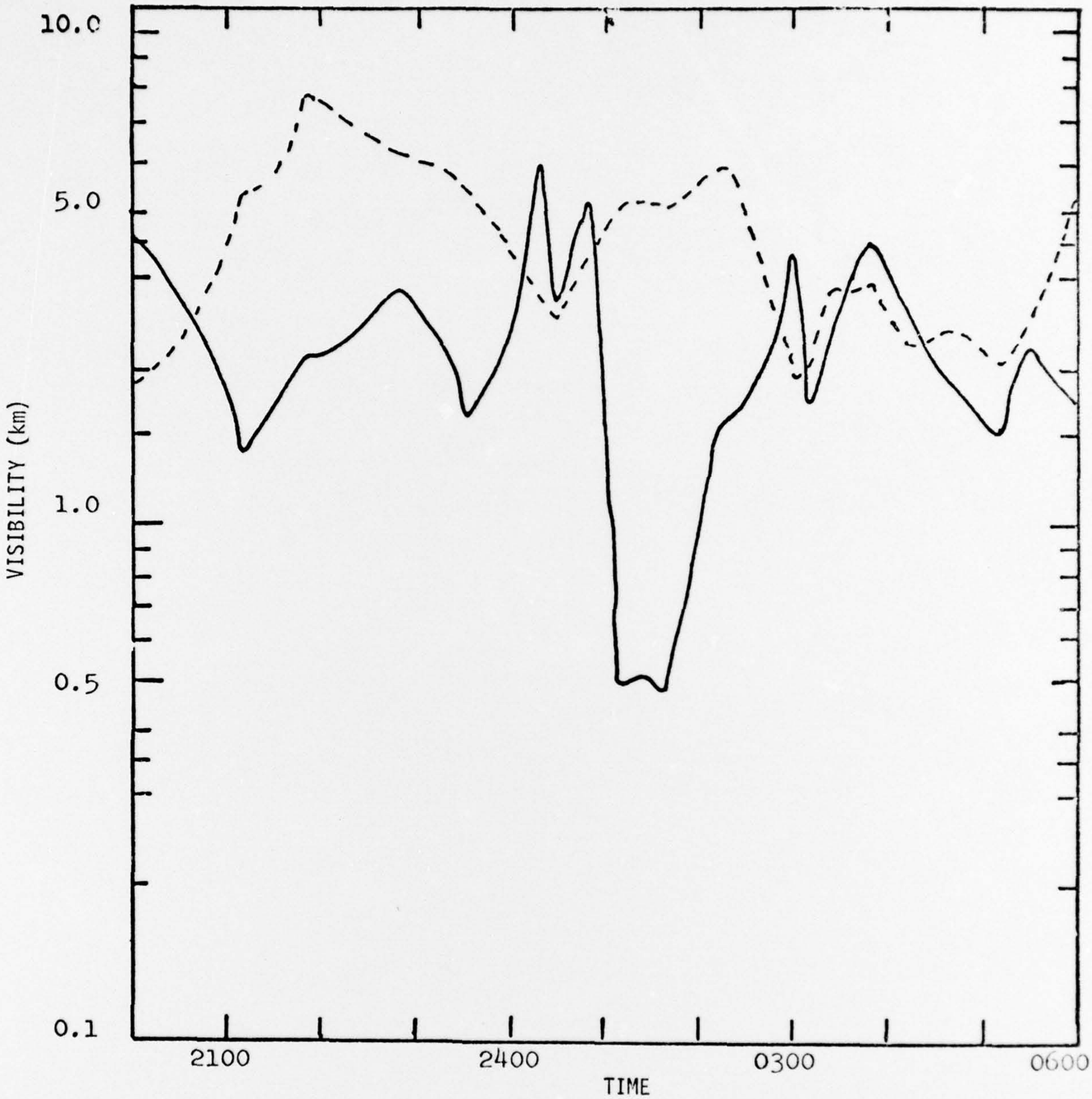


Figure 5. Visibility variation with local time.
—— Fog Data
--- Relatively Clear Air Data

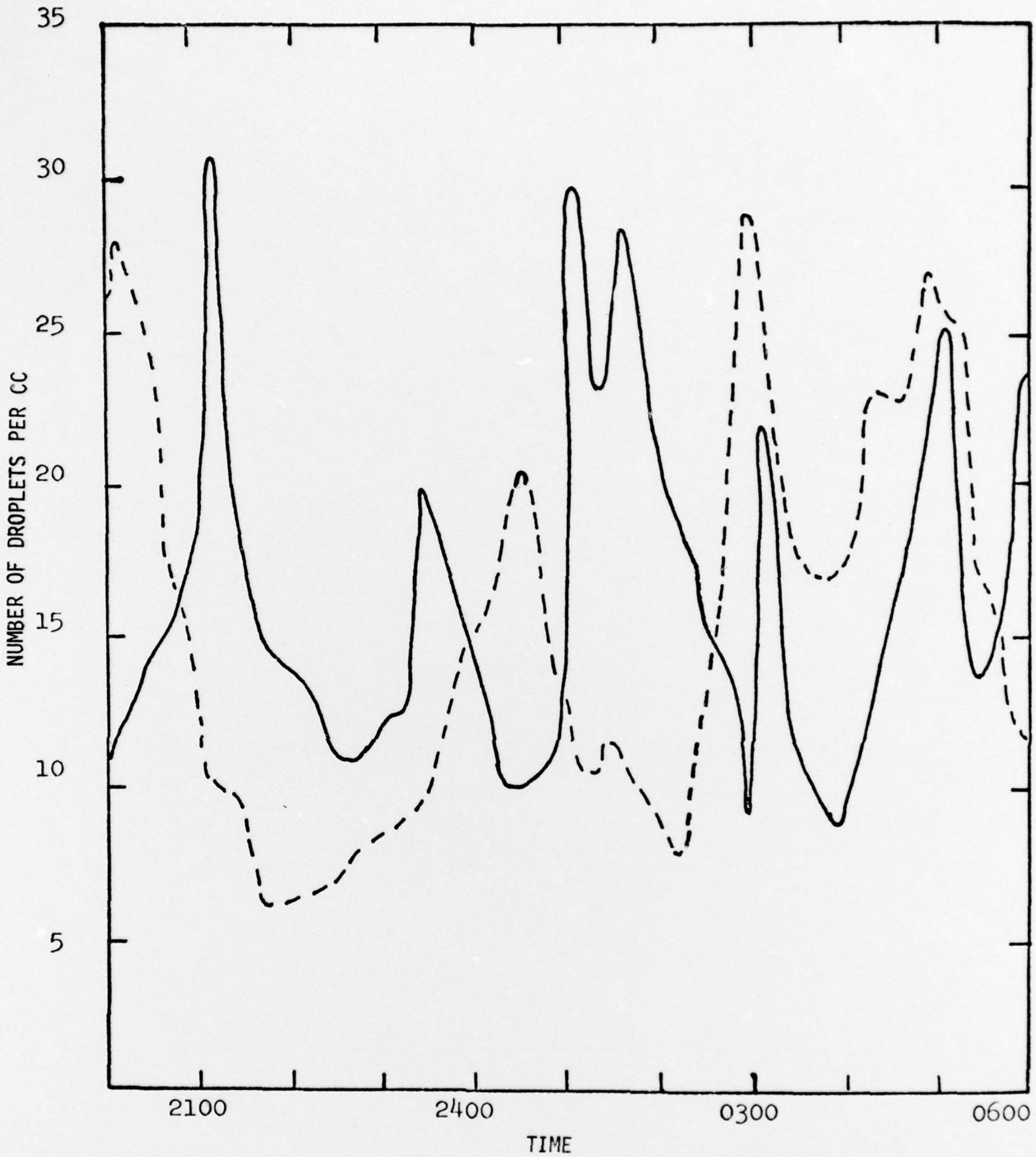


Figure 6. Total number of water droplets as a function of local time.
—— Fog Data
--- Relatively Clear Air Data

☆ U.S. GOVERNMENT PRINTING OFFICE: 1975 677-344/017

DEPARTMENT OF THE ARMY
ATMOSPHERIC SCIENCES LABORATORY
US ARMY ELECTRONICS COMMAND
AMSEL-BL-DP-P
WHITE SANDS MISSILE RANGE
NEW MEXICO 88002

OFFICIAL BUSINESS
Penalty For Private Use, $300

POSTAGE AND FEES PAID
DEPARTMENT OF THE ARMY
DOD 314

U.S. MAIL

NASA Scientific & Tech Info Fac
ATTN: Acquisitions Br
P. O. Box 33
College Park, Maryland 20740